BULLETIN 84 AUGUST, 1905

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND THE MECHANIC ARTS
AMES, IOWA

BOTANICAL SECTION

THE CEDAR APPLE FUNGI AND APPLE RUST IN IOWA

L. H. PAMMEL

1905
Republican Printing Company,
Cedar Rapids, Iowa.

BOARD OF TRUSTEES

Ex-Officio:

His Excellency, A. B. CUMMINS, Governor of Iowa.
HON. J. F. RIGGS, Superintendent of Public Instruction.

	Term Expires
First District—HON. H. M. LETTS, Columbus Junction	1910
Second District—HON. VINCENT ZMUNT, Iowa City	1910
Third District—HON. E. A. ALEXANDER, Clarion	1908
Fourth District—HON. ELLISON ORR, Waukon	1910
Fifth District—HON. W. R. MONINGER, Galvin	1906
Sixth District—HON. W. O. MCELROY, Newton	1908
Seventh District—HON. W. K. BOARDMAN, Nevada	1906
Eighth District—HON. GEORGE S. ALLYN, Mt. Ayr	1910
Ninth District—HON. JAS. H. WILSON, Adair	1908
Tenth District—HON. J. B. HUNGERFORD, Carroll	1906
Eleventh District—HON. W. J. DIXON, Sac City	1906

OFFICERS OF THE BOARD

HON. J. B. HUNGERFORD, Carroll	*Chairman*
PROF. E. W. STANTON, Ames	*Secretary*
HERMAN KNAPP, Ames	*Treasurer*

STATION STAFF

A. B. STORMS, M. A., D. D., President.
C. F. CURTISS, B. S. A., M. S. A., Director.
W. J. KENNEDY, B. S. A., Animal Husbandry and Vice-Director.
W. J. RUTHERFORD, B. S. A., Associate in Animal Husbandry.
A. T. ERWIN, M. S. A., Associate Horticulturist.
L. H. PAMMEL, B. Agr., M. Sc., Ph. D., Botanist.
H. E. SUMMERS, B. S., Entomologist.
G. L. MCKAY, Dairying.
P. G. HOLDEN, M. Sc., B. Pd., Agronomy.
W. H. STEVENSON, A. B., Soils.
————————, Farm Mechanics.
H. P. BAKER, M. F., Forestry.
E. E. LITTLE, B. S. A., M. S. A., Assistant in Horticulture.
J. W. JONES, Assistant in Agronomy.
WAYNE DINSMORE, B. S. A., Assistant in Animal Husbandry.
W. W. SMITH, B. S. A., Assistant in Animal Husbandry.
C. LARSEN, M. S. A., Assistant in Dairying.
G. I. CHRISTIE, B S. A., Assistant in Soils.
H. M. BAINER, M. A., Assistant in Farm Mechanics.
I. O. SCHAUB, B. S., Assistant in Soils.
L. G. MICHAEL, B. S., Chemistry.
C. E. ELLIS, B. S. A., M. S. A., Assistant in Chemistry.
R. E. BUCHANAN, B. S., Assistant in Botany.
CHARLOTTE M. KING, Artist.
E. S. GARDNER, Photographer.
WILL H. OGILVIE, Bulletin Editor.

Cedar Apple Fungi and Apple Rust in Iowa

BY L. H. PAMMEL

The subject of apple rust in this state has assumed considerable importance during the past season so that a treatment of the species of apple rust in Iowa will not be out of place.

A few years ago the writer of this bulletin prepared for the Division of Vegetable Physiology and Pathology, a paper on these rusts as affecting forest trees of the west. With the consent of Dr. Albert F. Woods, Chief of the Division, I present that portion of the above paper which deals with the apple rusts. I wish especially to express my thanks to Mrs. Patterson and the Division for the loan of material and for other assistance in the preparation of this paper.

During the month of June I received from a correspondent in Council Bluffs the following letter in regard to an apple rust which seriously affected his trees:

"I take the liberty of sending you a specimen of a fungus that infests my evergreen trees and wish you would kindly examine this fungus and write me what you think about it. Whether it will ultimately be the death of the trees? What causes it, etc.? Whenever it rains these fungi swell up like those I send you, as it rained last night. As soon as it dries, they, too, dry up like little hard needles. My evergreen trees were infected with these last year also. If it is possible, I would deem it a favor if you would write me what you think of the fungus, etc."

Somewhat later communications were received from other points of the appearance of the fungus on cultivated apple trees. During the month of August, the writer had occasion to visit the farm of Hon. W. R. Moninger, in Marshall county, where the fungus was very destructive to a small apple orchard belonging to Mr. W. W. Hixson. On a row of Wealthy apple trees which was next to a windbreak of Red Cedar, every tree of the Wealthy was badly diseased. Thousands of leaves were colored with yellow spots, giving the trees a yellowish look. In fact, few healthy leaves could be found on these trees. There were also some diseased leaves on other varieties in the second and third rows. One of these

was a sweet apple. I could not, however, learn the names of the varieties.

In August, Mr.- W. W. Thompson, Cedar Rapids, Nebraska, sent a specimen of the Wealthy apple from Nebraska very seriously affected with the apple rust. This was the fourth or fifth communication that we had received on the subject that season. The writer had previously made inoculations of the Cedar apple fungus on the cultivated apple at Ames, but without results, and was therefore surprised to see the cultivated apples affected with the rust. The occurrence of this fungus upon the cultivated apple in this state is

Fig. 1—Apple Rust, *Roestelia pyrata*, on Wild Crab. Photograph, Charlotte M. King.

therefore of great interest. Some conditions, no doubt, have brought about the infection of the Wealthy apple. It is to be regretted that the Wealthy, which is conceded to be one of the best apples in northern Iowa for general hardiness, should be affected with this disease. That the infection had resulted from the Red Cedar trees, admitted of no doubt.

During the summer, Mr. M. Parrott, of Aurelia, Iowa, sent the following communication to Wallace's Farmer:

"I would like to know what is the matter with my young orchard of seventy-five trees. It is all brown with some kind of blight. It has a double

row of cedars on one side. Some say it is from them. It came on all at once and enveloped the whole orchard, except two Martha crabs, which do not seem to be affected. Will it destroy the trees? If not, will it be a detriment to next year's crop? The trees bore heavily last year."

To which I replied as follows:

"This communication is certainly of interest because it is one of the few instances in the west where the apple rust has been found on the cultivated apple. The explanation is very simple. The cedar trees around the orchard contain the cedar apple fungus, and the cedar apple fungus spreads to the apple trees adjoining. It is rare for the fungus to appear on the cultivated apple in the west, and it would be interesting to know what the varieties are. It will, of course, somewhat affect the apple crop for next year."

Recently I had occasion to observe the cedar apple fungus in Eagle Grove. I observed an abundance of the cedar apple fungus on the haw and wild crab, but it was not on the cultivated apple trees near by.

On the Red Cedar trees the old galls of the cedar apple fungus (*Gymnosporangium macropus*) were still abundant. Some with their orange, gelatinous masses. The apple rust proved to be the apple rust (*Roestelia pyrata*,) commonly found on the wild crab. During September several communications from Ida county brought specimens of this apple rust chiefly on the Wealthy apple. Prof. Baker informs me that he found it common near Shenandoah, and Prof. Summers tells me that he observed it at many points in the state. The outbreak of the apple rust is certainly very unusual in this state. In my observations and experiments, extending over a period of fourteen years in the state, I have never seen the cultivated apple affected. That it may become a very serious enemy to apple culture in the state cannot be doubted. It will not be out of place to briefly consider the history and structure of the apple rust and cedar apple fungi of Iowa.

GYMNOSPORANGIUM

The species of the genus Gymnosporangium are widely distributed, both in the old and new world. The teleutosporic stage occurs on the *Cupressineae* of the conifers, while the aecidial stage, with one exception, occurs on the *Pomeae* of the order *Rosaceae*.

Historical. The genus, as generally accepted, was established by DeCandolle[1] from unpublished papers by Hedwig. The first mention of this fungus was by Franke[2] in his

1. Fl. Fr. 2: 216. 1805.
2. Speculum botanicum. 1638. Citation given by Oersted.

"*Speculum Botanicum.*" Micheli,[3] in 1738, used it as the type of his genus Puccinia. Linnaeus[4] first used the name Byssus. Dr. Kuntze[5] proposed to use the Puccinia which had long been applied to another type of rust. Dr. Arthur[6] states that in the interest of a stable nomenclature this generic name should be used. He named the two Indiana species, *Puccinia globosum* (Farl.) Kuntze (*G. globosum* Farl.,) and the other *Puccinia Juniperi-Virginianae* (Schw.) Arth. (*G. macropus* Lk.) This same nomenclature was not, however, adopted by Underwood.[7] Magnus[8] clearly states that Kuntze in accepting Haller's Puccinia was mistaken, since Haller's fungus did not belong to the *Uredineae*. In a more recent paper Arthur[9] adopts *Tremella*, as it is one of the three species of *Uredineae* mentioned by Linnaeus.[10] The early synonymy is given by Rees.[11]

When the species of Gymnosporangium were first described, it was not known that the cedar apple fungi were connected with an Aecidium having an entirely different appearance. Oersted[12] in 1865 established the genetic connection between *Gymnosporangium* and *Roestelia*. These results were later confirmed by DeBary[13] and other continental writers. Cramer[14] and Cornu[15] also suspected a genetic connection. The three species found by Oersted in Denmark were referred to three different species of *Roestelia*. Recent European writers[16] have somewhat extended the number of

3. Nova plant. genera. 213. 1729.
4. Fl. Lapp. 390 1737.
5. Rev. Gen. Pl. III.
6. Indiana plant rusts, listed in accordance with latest nomenclature. Proc. Ind. Acad. Sci. 1898: 174-186.
7. Moulds, Mildews and Mushrooms. 91 Underwood and Earle. The distribution of the species of Gymnosporangium in the South, Bot. Gazette 22: 255.
8. Bot. Centralbl. 77: 4.
9. Generic nomenclature of cedar apples. Proc. Ind. Acad. Sci. 1900: 131.
10. Sp. Pl. 1625. 1753. See also Gmelin Syst. 2: 1446.
11. Die Rostpilsformen der deutschen Coniferen Abhadl. d. Naturf. Gesellsch. Halle. 11: 51. 1869.
12. Bot. Zeit. 1865: 291.
13. Bot. Zeit. 1867: 222.
14. Ueber der Gitterrost der Birnbaume u seine Bekampfung. Sep. Schw. Landw Zeitschr. 1876. Solothurn.
15. Cornu Bull. Bot Soc. 25: 122, 221.
16. Tubeuf. Generations und Wirthswechsel unserer einheimischen Gymnosporangium—Arten und die hierbei auftretenden Form veranderungen. Centralbl f. Bakt. u. Parasitenk. 9: 89-98 167-171. *3f.* 1891.
Infektionen mit Gymnosporangium Arten. Forstl. Naturw. Zeitsch. 1893: 75.
Zeitschr. f. Pflanzenk 1: 110-114
Rathay. Oesterr. Bot. Zeitschr. 1880: 241.
Fischer. Ueber Gymnosporangium sabinae (Dicks) und Gymnosporangium confusum Plow. Zeit. f. Pflanzenk. 1: 193, 260.
Plowright Jour. Linn. Soc. Bot 24: 93, 1887.
Gardner's Chronicle. III. 4: 18-19 1888
Monograph Brit Ured. and Ustilag 232 Hartig Lehrbuch der Baumkrank. 53.
Textbook of the Diseases of Trees. English Transl, by Wm. Sommerville and H. Marshall Ward. 157.

species of the genus for Europe. Dr. W. G. Farlow[1] conducted some pioneer investigations in this country which resulted in establishing the genetic connection between some of the species of *Gymnosporangium* and their *Roestelia*.

To Thaxter,[2] however, more than to any one else in this country, we are indebted for clearing up many of the doubtful points that had existed in regard to the connection of some *Gymnosporangia* and their *Aecidia*.

Halsted[3] has published a few notes on the economic importance of the group, and some on the cultures obtained from *Gymnosporangium macropus*. To these we must add also the short notes of Seymour,[5] Stewart and Carver,[6] and of the present writer.[4]

All of these mycologists have aided in tracing the genetic connections of our species of *Gymnosporangium*. The accumulation of additional material from the west makes it highly desirable that more work be done, especially since one species is destructive to three cultivated plants, namely the pear, quince and service berry (*Amelanchier alnifolia*.)

The European species stand connected as follows:

GYMNOSPORANGIUM	ROESTELIA
G. Juniperinum (L.) Wint.	R. cornuta (Pers.) Fr.
G. Sabinae (Dicks.) Wint.	R. cancellata (Jacq.) Reb.
G. confusum, Plowr.	R. Mespili, DC.
G. clavariaeforme (Jacq.) DC.	R. lacerata (Sow.) Mer.
G. tremelloides, A. Br.	R. penicillata (Müll.) Fr.

The American species stand connected as follows:

G. clavipes, C. and P.	R. aurantiaca, Pk.
G. macropus, Lk.	R. pyrata (Schw.) Thax.
G. Ellisii (Berk.) Farl.	R. transformans, Ellis.
G. biseptatum, Ellis.	R. Botryapites, Schw.
G. globosum, Farl.	R. lacerata Am. Auct.
G. nidus-avis, Thax.	R. nidus-avis, Thax.
G. flaviformis (Atkinson) Earle.	R. flaviformis, Atkinson.
G. Bermudianum, Earle.	Aecidium Bermudianum, Farl.

1. The Gymnosporangia of cedar apples of the United States. Anniv. Mem. Boston Soc. Nat. Hist. 28 *2 pl.* 1880.
   Development of Roestelia from Gymnosporangia. Bot. Gaz. 11: 190.
   The Development of the Gymnosporangia of the United States. Bot. Gaz. 11: 234.
   Notes on some species of Gymnosporangium and Chrysomyxa of the United States. Proc. Am. Acad. of Arts and Sci 20: 311.
2. Thaxter. Notes on Cultures of Gymnosporangium made in 1887 and 1888. Bot. Gaz 14: 163.
   On certain cultures of Gymnosporangium with notes on their Roestelia. Proc. Am. Acad Arts and Sci. 22: 259.
   The Connecticut Species of Gymnosporangium. Bull. Conn. Agrl. Exp. Sta. 107: 6.
3. Apple Rusts, Rept. Comm. Agrl. U. S Dept. Agrl. 1888: 370-381. *pl. 11, 12.* 1889.
   Relations between Cedar Apples and Leaf Rust upon Crabapple. Bull. Dept. Bot. Ia. Agrl. Coll 1886: 59. 1888: 90.
4. Pammel, L. H. Jour Myc. 7: 102. Bull. Ia. Agrl Exp. Sta. 13: 41. Diseases of Foliage and Fruit. Rept Ia. St. Hort. Soc 28: 470
5. Orchard Rusts. Trans Am. Hort. Soc. 4: 152. f. 14. 1886.
6. Inoculation Experiments with *Gymnosporangium macropus*, Lk. Proc. Ia. Acad. Sci. 3: 162.

Fig. 2. Cedar Apple galls, the so-called Cedar Apple on Red Cedar. *Gymnosporangium macropus*. The other stage occurs upon the apple. Photograph, Charlotte M. King.

Asiatic species stand related as follows:

G. Cunninghamianum, Barcl.	A. (R.) Cunninghamianum, Barcl.
G. Japonica, Syd.	R. Koreaensis, Henn.

Unconnected or doubtful:

G. speciosum, Pk. Am.	R. Harknessiana, E. and E.
G. Nelsoni, Arth. Am.[1]	R. Nelsoni, Arth.

The nomenclature employed by Arthur for the American species is as follows:

Tremella Juniperina, L.	G. juniperinum (L.) Wint.
T. Sabinae, Dicks.	G. Sabinae (Dicks.) Wint.
T. clavariiformis, Jacq.	G. clavariaeforme (Jacq.) DC.
T. penicillata (Müll.) Arth.	G. tremelloides A. Br.
T. Mespili (DC.) Arth.	G. confusum Plowr.
T. Juniperi-Virginianae (Schw.) Arth.	G. macropus, Lk.
T. botryapites (Schw.) Arth.	G. biseptatum, Ellis
T. clavipes (C. and P.) Arth.	G. clavipes, C. and P.
T. Ellisii, (Berk.) Arth.	G. Ellisii, Ellis.
T. speciosa (Pk.) Arth.	G. speciosum, Pk.

The morphological and biological characters are admirably treated by Farlow,[2] DeBary[3] and Richards.[4]

In a short paper Richards notes the different types of germination of teleutospores. It had previously been observed by Oersted, Farlow, Rees, Körnicke[5] and Dietel[6] that in *G. clavariaeforme* there are two types of spores. In this species the inside spores are symmetrical, having their hyaline walls and fine granular contents; the spores on the outside are not symmetrical, the upper cell is much more blunt than the lower. The walls are thick and dark brown. The thick-walled spores germinate as is common in teleutospores, with promycelia producing lateral sporidia. From the thin-walled spores there develops a long undivided tube which does not bear sporidia; in this there is a resemblance to uredo spores. Indeed, Kienitz-Gerloff,[7] who studied these spores somewhat carefully, regarded them as uredo spores, but Richards does not agree with him.

The writer has observed a similar mode of germination in *G. speciosum.*

---

1. It should be noted here that Arthur in describing a new species, *G. Nelsoni*, does not use *Tremella.*
   Bull. Torrey Bot. Club. 28: 665.
2. lc.
3. Comparative Morphology of the Fungi, Mycetozoa and Bacteria.
4. Uredo-stage of Gymnosporangium. Bot. Gaz. 14: 211. *pl. 17.*
5. Hedwigia. 16: 26
6. Ueber das vorkommen von zweierlei Teleutosporen bei der Gattung Gymnosporangium. Hedwigia. 28: 99. 1889.
   Bermerkungen uber einige in und auslandische Rostpilze. 28: 22.
7. Die Gonidien von Gymnosporangium clavariaeforme. Bot. Zeit. 46: *pl.7.* 389.

GYMNOSPORANGIUM GLOBOSUM

The *G. globosum* Farl. is a well known species of eastern North America.[1] It was described by Farlow from Massachusetts, and has been referred to by Peck,[2] Halsted,[3] Thaxter,[4] and other writers.

Fig. 3—Perennial Cedar Apple fungus, *Gymnosporangium globosum* on Red Cedar. Photograph by Charlotte M. King.

1. The Gymnosporangia or Cedar Apples of the United States. Ann. Mem. Boston Soc. Nat. Hist. 18 *pl. 1., f. 7-11.*
   Bull. Bussey Institute 1: 433. 2: 225.
2. Peck, C. H., Apple Rusts. N. Y. State Botanist, 25: 89.
3. Halsted, Rep. U. S. Dept. Agrl., 1888: 370. *pl. 11-12.*
4. Pammel, L. H., Jour. Myc., 7: 102.
   Seymour. Orchard Rusts. Am. Hort Rep. 4: 152. *f. 14.*
   Sargent, C. S. Silva 10: 73.
   Underwood & Earle. Bot. Gaz. 22: 225.

Geographical Distribution. Its occurrence in the United States is by no means limited to the eastern states. It has been recorded by Trelease[1] from Wisconsin. In 1883 and 1884, I saw it quite common on some Red Cedars at Madison, Wisconsin, and in the same year found the common form in the vicinity of La Crosse on native *Juniperus Virginiana* to be *G. macropus*. Arthur[2] records it from Indiana, Underwood and Earle[3] from Alabama, Earle and Tracy from Mississippi, and Thaxter[4] from North Carolina. It has also been found in central Iowa by myself.[5]

In the herbarium of the Division of Vegetable Physiology and Pathology, it is represented by specimens in this splendid collection from Green Castle (Biol. Survey Ser. 1, No. 45,) Buffalo (Clinton,) Coeymans, Albany (Peck), Alcove (Shear.) It has also been sent to me from Long Island (Sirrine) and southern Missouri.

It is certainly a rare fungus in the vicinity of Ames as no more specimens have been found, even after careful search. It was evidently not found in central Iowa in 1884 or earlier by Bessey[6] and Arthur since it is not reported, nor are there any specimens in the herbarium, the *G. macropus* being the only species reported by Dr. Bessey[7] from central Iowa, while Arthur lists *G. macropus* from three localities and *G. clavariaeforme* and *G. clavipes** from northeastern Iowa. L. R. Walker has, however, found the *G. globosum* on *G. Virginiana* near Clermont in Fayette county.

In the herbarium of the University of Minnesota, the species is represented by specimens from Osceola county, Wisconsin, E. M. Freeman (995) and Grey Cloud Island, Washington county, Butler and Hibbard.

Nelson[8] who has listed the parasitic fungi of Wyoming, does not include this or any other species for that state, but I have found the *G. globosum* near Laramie and in southwestern Wyoming.

The aecidium stage of this fungus or the Roestelia occurs on *Crataegus*, *Pyrus malus*, *P. Americana* and *Cydonia vulgaris* and is generally referred to by American authors as

1. Parasitic Fungi of Wis. 29.
2. Indiana Plant Rusts listed in accordance with latest nomenclature. Proc. Ind. Acad. Sci. 1898: 174–186.
3. Bot. Gazette 22: 257. A Prel. list of Alabama Fungi. Bull. Ala. Agrl. Exp. Sta. 80: 212. F. S. Earle in Mohr's Pl. Life of Ala. Contr. U. S. Nat. Herb. 6: 185.
4. Notes on Cultures of Gymnosporangia. Etc. l. c. 170.
5. Jour. Myc. l. c.
6. Bull. Ia. Agrl. Coll. 1884: 144, 162.
7. Prel. List of Iowa Uredineae. Bull. Ia. Agrl. Coll. 1884: 163.
8. Ann. Rep. Wy. Agrl. Exp. Sta. 10: 30.

*Since writing the above, *G. clavipes* has been found in Boone county on the Red Cedar.

R. lacerata. Thaxter[1] refers the aecidium of *G. globosum* to *R. lacerata* distributed by Ellis in his North American Fungi, No. 1085a. Farlow[2] also discussed the genetic connection of this *Gymnosporangium*, stating in 1886 that *G. globosum* was as great a puzzle as ever.[3]

General Characters. The galls vary a great deal in size, from one-fourth to an inch in diameter, the smaller usually occurring on the green; the larger, more or less woody ones on older branches. The gall is very irregular, marked by small brown places, depressed scars, and small protruding sporiferous masses. In *G. macropus* the chocolate brown gall is smooth with the exception of small papillae. The small scars from the sporiferous masses of previous seasons are prominent and will at once distinguish *G. globosum*. During the late spring in May small truncate or wedge-shaped dark brown sporiferous masses protrude. On the addition of water these spore masses swell and are yellowish orange, one-fourth to one-half inch long with a widened base. The *Roestelia* occur in definite yellow spots from a quarter to half an inch in diameter; spermagonia, blackish on upper surface of the leaf; aecidia, on the lower surface of the thickening of the leaf, few, clustered or numerous, long, slender, recurved, soon splitting and becoming fimbriate; before spores are discharged, pale yellowish in color, later greyish white. Ultimately the whole aecidium cups disappear, leaving short cup-like depressions in the pulvinate swellings.

Microscopical Characters. The dark brown sporiferous masses contain light orange colored ovate spots with uniformly thickened walls, apex rounded or somewhat acute, slightly constricted in the middle, 19-21$^{\mu}$ x 38-45,$^{\mu}$ pedicels long, of equal diameter, and on the addition of water becoming gelatinous.

In addition to the two-celled spores, a few one-celled spores also occur, which are shorter than the two-celled and are somewhat thicker walled, but otherwise resemble the two-celled spores.

1. Thaxter Notes on Cultures of Gymnosporangium made in 1887 and 1888. Bot. Gazette 14: 163
2. Notes on Some Species of Gymnosporangium and Chrysomyxa of the United States. Proc. Amer Acad. of Arts and Sci 20: 311. 1885
   The development of the Gymnosporangia of the United States. Bot. Gazette. 11: 234 1886.
3. This species has been distributed by Ellis. N. Am. Fungi. 1478, collected by Peck, also by Von Thuman. Myc Univ. 2139. Albany (Peck,) Seymour and Earle. Econ Fungi 230a, 230b, 230x. Ellis and Everhart. N. Am. Fungi. 2947. Alcove, N. Y. (Shear)
   The aecidium has been distributed as follows: Seymour and Earle. Econ. Fung. 231a, 231b, 231c, 232a, 232b, 233a. Ellis and Everhart. N. Am. Fung. 2998. Shear. N. Y. Fung. 79.

The aecidia are hypophyllous with long narrow peridial cells 15-20^{u} x 55-97.^{u} The spores are borne in chains arising from the hymenium, brownish in color, nearly spherical or somewhat oblong, wall uniformly thickened with minute roughenings 19-3^{u} in diameter.

Genetic Connection. Owing to the age of the material examined, germination was not very successful; each cell produced one promycelium, but sporidia were not formed. I have examined fresh material this spring in which two to four promycelia were produced with their sporidia. Farlow[4] found usually four promycelia for *G. globosum*. The gelatinous masses are eagerly sought by insects and these undoubtedly carry the sporidia or even spores to neighboring plants of *Amelanchier* or *Crataegus*. Wind does not perhaps convey so much infectious material as insects. When the sporidia germinate upon *Amelanchier*, somewhat circumscribed spots appear in about ten days which may later coalesce.

This *Gymnosporangium* is common in the Black's Fork district, and I am satisfied infection does not take place in the Uintah mountains along Black's Fork much before the middle of July as no aecidia were found during the early weeks of our stay there.

The aecidial spores are carried by the wind or insects and, when falling on cedar trees, usually neighboring trees, germinate and produce the galls which break through the stem where the leaf is attached. The mycelium stimulates its host to the formation of parenchymatous tissue. The aecidium stage was not found in proximity to the Red Cedar trees although the *Roestelia* was found on the leaves and branches of *Crataegus rivularis* where it produced large swollen distortions.

The aecidial stage of this fungus also occurs in Montana. Specimens examined by the writer in the Herbarium of the Office of Vegetable Pathological and Physiological Investigations from Bozeman, collected by A. B. Seymour, are referable to this species. In another connection reference has been made to the occurrence of this *Gymnosporangium* in northeastern Iowa. We also have the aecidium from Postville, northeastern Iowa, collected by Miss Charlotte M. King on *Crataegus punctata*.

The results of Dr. Thaxter seem to show beyond a doubt that the *Roestelia lacerata* Am. Auct. is connected with this

4. l. c. *pl. 1. f. 5, 6, 9.*

species. Some excellent material was sent in from F. B. Laney, Springfield, Missouri. The spores were nearly ready to germinate. They were placed in water. In the course of twenty-four hours, germ tubes were produced. The members of the family *Pomeae* on the college grounds were sprinkled with the spores, with the following results:

Name of Species	Date of Sowing	No. of Leaves	No. of Flowers	Results
Pyrus aucuparia	May 7	3		0
" communis	" 5	7	7	0
" Iowensis	" 7	16	13	0
" Mercer Co. crab	" 7	10		0
" hybrid (Soulard)	" 7	10	9	0
" Malus	" 5	6	6	0
" Sinensis	" 5	17	15	0
Amelanchier alnifolia	" 5	3	8	0
Crataegus mollis	" 7	leaves		0
" pinnatifida	" 7	4		0
" punctata	" 7	4	7	0

Fig 4—*Roestelia aurantiaca* on quince. Photograph W. Paddock.

In not a single case did spermagonia appear.

Hosts. There are now three known hosts of *Gymnosporangium globosum*, *Juniperus Virginiana* in the eastern and central states, *J. scopulorum* in the region between the Missouri river and the Rocky mountains and *Juniperus occidentalis* var. *monosperma* on the western slope of the Rocky

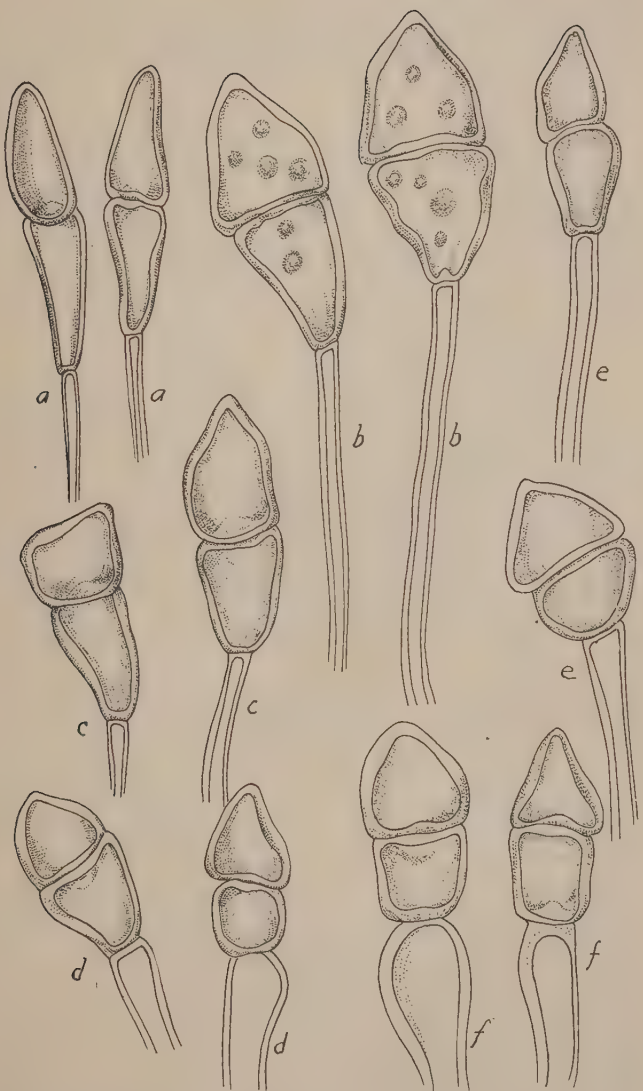

Fig. 5. Two-celled spores of Cedar Rusts, Gymnosporangium. a. *G. clavariaeforme*. b. *G. globosum*. c. *G. macropus*. d. *G. nidus-avis* on *J. Virginiana*. e. *G. Nelsoni* on *J. scopulorum*. f. *G. clavipes* on *J. Virginiana*. Charlotte M. King.

mountains. *Crataegus* hosts are uncertain because of the many changes made in the nomenclature of the Crataegi, but it is common on *C. punctata*, *C. coccinea* and *C. mollis*. *Amelanchier alnifolia* is also a host. It has not been found near Ames.

Economic. In the Uintah mountains this *Gymnosporangium* is common on *Juniperus occidentalis* var. *monosperma*, frequently covering all the younger branches; thousands of the perennial galls may be found on a single tree, both young and old trees being affected. The fungus seriously impairs the vitality of trees attacked and ultimately destroys them. The species is also common in Clear Creek Canon region near Idaho Springs, Colorado.

GYMNOSPORANGIUM MACROPUS

The common cedar apple fungus of Iowa, *Gymnosporangium macropus*, was not found by me in the Rocky mountains, though doubtless it occurs as it is reported from Nebraska by Dr. Bessey and others. It was first named *Gymnosporangium juniperi-virginianae*[1] by Schweinitz in 1882, but Link named it *G. macropus*,[2] which is now generally used. It is undoubtedly the most abundant of all the species of Gymnosporangium in the Mississippi Valley. Certainly it is the most abundant of the species in Iowa. Many of the American references under *Gymnosporangium* mention this species.

An excellent account of this species was given by Dr. Halsted.[3] Since Dr. Halsted's account, I have made some experiments on the wild crab and the cultivated apple. The experiments of Profs. F. C. Stewart and G. W. Carver along the same line are also of interest in this connection. In Iowa this fungus is so abundant as to seriously impair the vitality of the Red Cedar tree as well as the adjacent wild crab,

1. Syn. Fung. Car. Sup. 74. No. 504. 1882.
2. The principal synonyms are given by Halsted Rep. U. S. Comm. Agrl. 1888: 370. *pl. 11-12.*
   Gymnosporangium juniperi-virginianae, Schw. Syn. Fung. Carl. Sup. 74. No. 504. 1822.
   Podisoma juniperi-virginianae, Fr Syst. Myc. 3: 57. 1832.
   Podisoma macropus, Schw. Syn. Fung. Am. Bor 307. No. 3096.
   Sprague's Contr. N. E, Mycol. 329. Curtis Pl N. C. 121.
   Pck's Rep. N. Y. St. Mus. Nat. Hist 23: 57.
   Exsiccati: Ravenel Fung. Car. No 85. Ellis N. A. F. No 270.
   Thum. Myc. Unv. No. 148.
   The following papers describe the species in detail:
   Tubeuf Pflanzenk. 415.
   Burrill. Parasit. Fung. III. 210.
   Saccardo Syll Fung 7: 740.
   Farlow Mem Boston Soc. Nat. Hist. 1880
   Underwood and Earle. Bot. Gazette. 22: 225.
3. Rep. U. S. Dept. Agrl 1888: 370. *pl. 11-12.*

Pyrus Iowensis, and recently the cultivated apple. The aecidium is less common on the Crataegus. So far as I know, the aecidium was not general upon the culti-

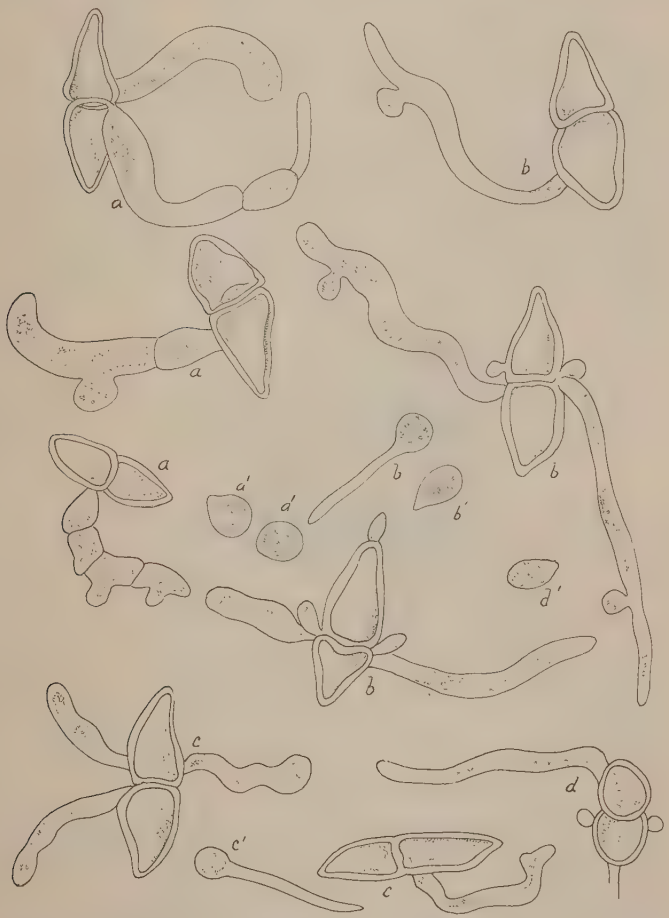

Fig. 6—Two-celled germinating teleutospores of the Cedar Rusts. a. *G. macropus*. b. *G globosum*. c. *G. clavariaeforme*. d. *G. nidus-avis*. Charlotte M King.

vated apple in the state until 1904, although Prof. Summers thinks he saw some in 1903. In the east it is common upon some varieties of cultivated apple.

The stems of the wild crab are frequently much distorted through the effects of this fungus. The fruit is also frequently affected.

General Characters. The species is most closely allied to *Gymnosporangium globosum*. The chocolate brown galls of variable size are fully formed in September or October. During the month of April small brownish masses protrude. These are surrounded at the base by the raised epidermis of the epidermal tissue of the gall. When fully mature, the sporiferous masses are cylindrical acuminate, from one-half to one inch in length, and become yellow when moistened. The first appearance of the fungus upon the wild crab is an orange patch varying from 1-16 to ¼ of an inch across, or occasionally somewhat larger. This spot bears minute dark or yellowish points upon the upper side, the spermagonia. The spermagonia are followed in a short time by the cluster cup or aecidia frequently arranged in a circle on the lower surface of the leaf. The wall of the aecidium or peridium splits into numerous fine threads. The peridial cells are usually curved.

Microscopic Characters. The teleuto spores are two-celled, ovate to acuminate and slightly constricted in the middle, the apex somewhat papillate. 15-20 x 46-60.^{u} Promycelium from each cell variable, two to four. The gall disappears in the course of the summer or in some cases may remain hanging on the trees for months. Under favorable conditions the sporiferous mass may produce spores in condition to germinate in from one to three weeks, and in extreme cases in six weeks, depending upon the condition of the weather. In the spring of 1902 the time was about three weeks in April and May. In 1904 spores were observed in the middle of July, making fully eight weeks.

The aecidia spores are brownish or nearly chocolate colored, smooth or frequently polygonal, 26-33^{u} in diameter. The peridial cells are elongated, frequently curved, with transverse striae, from 90-110^{u} long. The spermagonia make their appearance in from 10 to 18 days after inoculation of the plant.

A comparison of the peridial cells and spores of *Gymnosporargun macropus* on *Crataegus punctata*, the Cultivated

Apple and Mercer County Crab, *Pyrus Iowensis* shows as follows:

Species	Spores	Peridial Cells
Cultivated Apple.....	16.6–28–6 and 19.21u x 19–22u	75 86 8u x 13–14u
Pyrus Iowensis.....	2[illegible]4–22.4u x 14–14.5u	57–60–92u x 14–16u
Crataegus punctata.....	16.8–19.6–22.4u x 15–16u	81–112u x 10½–12u

Genetic Connection. The repeated experiments made by Dr. Thaxter, Dr. Farlow, Prof. Halsted and others, leave no doubt about the genetic connection between *Gymnosporangium macropus* and *Roestelia pyrata*. It is however, singular that a fungus so destructive in the east and south to the cultivated apple did not occur upon this host in the states of Iowa, Minnesota and Wisconsin till 1904. Although it is common upon the wild apple and Crataegus and seldom upon the Soulard crab.

Fig. 7—Apple Rust on Wild Crab, *Pyrus Iowensis*. The other stage occurs on the Red Cedar. Photograph by Charlotte M. King.

In the *Crataegus punctata* as well as in the Crataegus *mollis* the peridial cells extend much longer beyond the surface of the leaf, and they are more finely lacerate.

In the *Pyrus Iowensis* the cups are shorter, darker brown and the peridial cells do not cling together as in the Crataegi.

In the cultivated apple the cups are much smaller than either of the other host plants. They project but slightly beyond the surface of the leaf. Although the red cedar trees bearing an abundance of the Gymnosporangium may be in close proximity to the cultivated apple, yet in no case was the *Roestelia pyrata* observed by me upon the cultivated apple until the season of 1904.

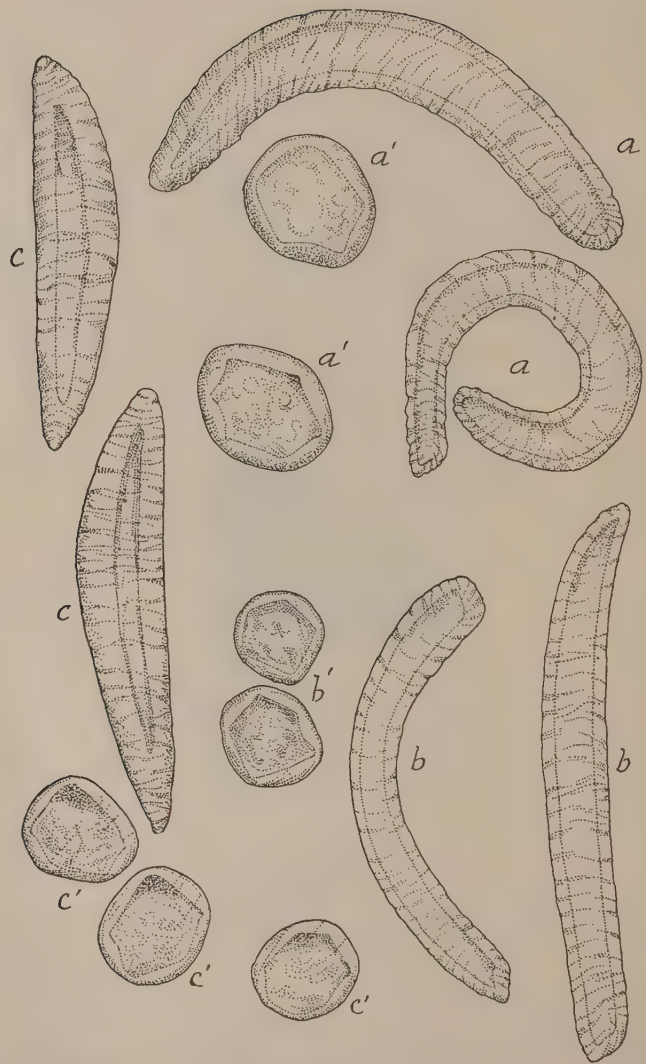

Fig. 8—Peridial cells and spores of *Roestelia pyrata*. a. Peridial cells. a'. Spores from cultivated apple. b. Peridial cells. b'. Spores from Crataegus. c. Peridial cells. c'. Spores from Mercer county crab (*Pyrus Iowensis*.) Greatly enlarged and all drawn to the same scale. Charlotte M. King.

A number of years ago I made some experiments with *Gymnosporangium macropus* upon *Amelanchier*, *Pyrus malus*, *Pyrus Iowensis* (Mercer county crab,) and although the Mercer was budded upon common *Pyrus malus*,

Fig. 9—Apple Rusts, *Roestelia pyrata*. a On *Crataegus mollis*. b. Clusters of cups. c. Single cups. d. On cultivated apple. e, f. Cups showing peridial cells. Photograph, Charlotte M. King.

the leaves and fruit of the Mercer county crab became affected while those of *Pyrus malus* did not. Some years ago Profs. F. C. Stewart and G. W. Carver[1] also made some experi-

1. Proc. Ia Acad Sci. 3: 162.

ments with *Gymnosporangium*. The results are of sufficient interest in this connection to quote from the paper.

"The connection of *Gymnosporangium macropus* with *Roestelia pyrata* has been established beyond question by Dr. Thaxter.[1] The inoculation experiments here reported were not undertaken for the purpose of obtaining further information concerning the relationship existing between the two forms of the fungus, but rather to ascertain why the cultivated apple in central Iowa should be free from Roestelia. Although the field has been thoroughly canvassed nearly every season during the past twenty-five years, no species of Roestelia has ever been taken on any variety of cultivated apple in the vicinity of Ames, Iowa. More than this, repeated efforts to artificially inoculate various varieties of cultivated apples with *Gymnosporangium macropus* have failed.

"In the spring of 1886, Dr. Halsted[2] inoculated *G. macropus* on two varieties of cultivated apple (Rawles' Janet and Tallman Sweet,) wild crab, *Pyrus coronaria*,[3] pear, mountain ash, *Pyrus semipinnata*, several species of hawthorn and two forms of Juneberry on the grounds of the Iowa Agricultural college, Ames, Iowa. In no case did Roestelia appear on the cultivated apples. He[4] says: 'The individual experiments numbered among the hundreds, and in every case there was a perfect failure of the *Gymnosporangium* to grow except with the crab apple, where the inoculation was most emphatic.' Further inoculations were made the following season, 1887. He says:[5] 'During the present season cultural experiments with the native cedar have been carried out by special students. It is an easy matter to inoculate the wild crab with this, but only failures have attended tests upon other plants.' In 1893 Prof. L. H. Pammel[6] made some inoculation experiments at Ames. A tree of the variety Tetofsky had been top worked with Fluke crab, which is an improved variety of *Pyrus coronaria; G. macropus* was inoculated upon both parts of the tree on the same day, with the same cedar apple. In due course of time, Roestelia appeared upon the Fluke crab portion of the tree, but not a single leaf of the Tetofsky portion was affected. Inoculations were also made upon pear, Japan quince (*Cydonia Japonica*,) cultivated apple and shadbush (*Amelanchier alnifolia*,) but these all proved failures."

---

1. On certain cultures of Gymnosporangium with notes on their Roesteliae. Am. Acad. Arts and Sci., 1886. 259.
2. Bull. Ia Agrl. Coll. from the Bot. Dept. 1886: 59-64.
3. Bailey considers the wild *Pyrus* of Iowa to be specifically distinct from *P. coronaria*. He uses the name, *Pyrus Iowensis*, given by Wood. See L. H. Bailey's Notes from a Garden Herbarium VI: The Soulard Crab and its rise. The American Garden. 12: 469.
4. l. c 63.
5. Bull. from Dept. of Botany. Ia. Agrl. Coll. Feb., 1888: 91.
6. Diseases of Foliage and Fruit. Rept. Ia. St. Hort. Soc. 29: 470. 1893.

RESULTS OF INOCULATION EXPERIMENTS

"The following table presents in a condensed form the results of the experiments on Long Island:

VARIETY	MATERIAL USED	CONDITION JUNE 15	CONDITION JUNE 29	CONDITION AUGUST 21
Yellow Transparent	Ia. *G. macropus*	No *Roestelia*	No *Roestelia*	No *Roestelia*
	N. Y. *G. macropus*	No *Roestelia*	No *Roestelia*	No *Roestelia*
Red Astrachan	Ia. *G. macropus*	Yellow spots on a few leaves	No further development	No further development
	N. Y. *G. macropus*	Yellow spots on a few leaves	No further development	No further development
Ben Davis	Ia. *G. macropus*	Not observed	Yellow spots a few leaves	No further development
	N. Y. *G. macropus*	Not observed	Yellow spots a few leaves	No further development
Red Pippin	Ia. *G. macropus*	No *Roestelia*	No *Roestelia*	No *Roestelia*
	N. Y. *G. macropus*	No *Roestelia*	Roestelia appearing	Partially developed
Maiden's Blush	Ia. *G. macropus*	*Roestelia*	Continuing to develop	Aecidia well developed
Wealthy	Ia. *G. macropus*	*Roestelia* appearing	Continuing to develop	Aecidia well developed

"All inoculations with N. Y. *G. macropus* were made May 18.

"All inoculations with Iowa *G. macropus* were made May 24.

"The experiments at Ames, Iowa, were conducted at the Agricultural college. May 26, 1895, *G. macropus*, from New York, was inoculated on Yellow Transparent, Grimes' Golden, Duchess of Oldenburg, Whitney's No. 20 and *Pyrus coronaria*. A large number of leaves on one tree of each were inoculated. In each case, some of the leaves were rubbed on both surfaces with the moistened cedar apple horns, while others were inoculated by making punctures with a sterilized scalpel. On the same day other trees of the same varieties were inoculated in the same manner with *G. macropus* collected in Iowa. All of the inoculations, except those on *Pyrus coronaria*, failed. But the *Pyrus coronaria* trees were so completely covered with *Roestelia* that scarcely a single perfect leaf could be found. What part of this was due to artificial and what part to natural inoculation, it is impossible to say. It simply shows that the season was a favorable one for *Roestelia*.

"Our experiments at Ames are entirely in accord with those made by Dr. Halsted and Professor Pammel. Taken in connection with our experiments on Long Island, they show that some varieties (notably Yellow Transparent) are wholly exempt from *Roestelia pyrata* and that there is good reason for believing that the absence of *Roestelia* from cultivated apples in Iowa is not wholly due to unfavorable climatic conditions, but chiefly to the fact that the varieties grown there are not susceptible to the disease. The severe climate of this section has obliged orchardists to abandon all except the most hardy varieties. These are mostly either Russian varieties or varieties which have originated in the northwest. However, the fact cannot be overlooked, that Wealthy, a variety shown by our own experiments to be very susceptible on Long Island, is frequently planted in Iowa, Wisconsin and Minnesota and is there exempt from *Roestelia*. We have by no means a complete solution of this problem.

"In the Long Island experiments it is interesting to note that while some varieties showed themselves wholly exempt and others were susceptible, there were also varieties which represented intermediate degrees of susceptibility. Yellow Transparent showed no signs of *Roestelia*; Maiden's

Blush and Wealthy contracted the disease readily and matured aecidiospores; on Ben Davis and Red Astrachan the Roestelia started to grow but never reached maturity; on Red Pippin, only part of the aecidiospores matured."

In 1901 we had an opportunity to try the experiments with *Gymnosporangium macropus* from three different sources, namely Missouri, Long Island and New York. We tried ten different hosts and in but few cases did we obtain positive results.

INOCULATION EXPERIMENTS, 1901

INFECTION RESULTS. MATERIAL FROM SPRINGFIELD, MISSOURI

Name of Host Species	Date of Inoculation	No. of Leaves	No. of Leaves	Results of Inoculation
Pyrus aucuparia	May 7	3		0
" communis	" "	5	6	0
" Iowensis	" "	Leaves	Flowers	Spermagonia and aecidia
" " Soulard Crab	" "	"	"	0
" " Mercer	" 8	6	5	Spermagonia and aecidia
" malus	" 7	5	5	0
Amelanchier alnifolia	" "	5	12	0
Crataegus mollis	" 8	Leaves	Flowers	Spermagonia and aecidia
" pinnatifida	" 7	6	9	June 1 " " "
" punctata	" 6	Leaves	Flowers	0

INFECTION RESULTS. MATERIAL FROM LONG ISLAND

	Date	Results
Pyrus aucuparia	May 13	0
" communis	" "	0
" Iowensis	" "	Spermagonia, later aecidia
" " Soulard	" "	0
" " Mercer	" "	Spermagonia, later aecidia
" malus	" "	0
Amelanchier alnifolia	" "	0
Crataegus mollis	" "	Spermagonia, later aecidia
" pinnatifida	" "	" " "
" punctata	" "	0

GYMNOSPORANGIUM CLAVIPES

In the Rocky mountain country there occurs a fungus on *Juniperus scopulorum* that has generally been referred to this species first described by Cooke and Peck,[1] as common in New York. and reported by Dr. Farlow[2] as frequently observed in the Atlantic states from Massachusetts (Thaxter, Farlow, etc.) to Florida, and collected in New Jersey by Ellis,

1. Rept. N. Y. St. Mus. Nat. Hist. 25: 89.
Jour Quekett Mic. Club. 2: 258. Grevillea 3: 190.
2. Bull. Bussey Inst. 2: 226.
The Gymnosporangia or Cedar Apples of the U. S. 21.

Pennsylvania by Michener, North Carolina by Curtis, and in South Carolina by Ravenel. The fungus is common in Mississippi where Prof. Tracy has found it at different points. Prof. Underwood and Earle also report it from Alabama and Prof. G. W. Carver has sent us some fine material from Tuskeegee.

This fungus is not, however, common in the Mississippi Valley. Arthur reports it from northeastern Iowa on *Juniperus Virginiana* collected by the well known student of *Uredineae*, Prof. E. W. D. Holway.[2]

I have not seen the specimen, but it may possibly be *G. nidus-avis* as Prof. Holway has supplied me with this from northeastern Iowa.

I have, myself, found some excellent material on the Red Cedar near Moingona in Boone county this spring, May 13, 1905.

Roestelia aurantiaca which is connected with this *Gymnosporangium* was first described by Peck.[3]

General Characters. Upon the scaly branches of the Red Cedar which are slightly swollen, develop the small, nearly pyriform or globose and inconspicuous sori which are hidden in the bark. They are light brown when dry, becoming conspicuous orange when moistened, and about a quarter of an inch high. The fungus causes a slight swelling of the leaves which become pointed and somewhat larger than normal.

The Roestelia. The aecidial stage of this species is *R. aurantiaca* which has for hosts the pear, quince, and *Amelanchier*. The aecidia closely collected on young and swollen fruits and stems, appear bright orange from the spores which retain their color for a considerable length of time; the peridia erect or somewhat curved, are about one quarter of an inch long, tubular, white, shining and toothed at the apex.

Microscopic Characters. Teleutospores elliptical, obtuse with wall somewhat thicker at the apex, 18-26$^{\mu}$ x 37-41,$^{\mu}$ pedicels swollen, as wide as the spores or wider, often somewhat inflated. The spores in Ellis and Everhart N. Am. Fung. 1083a are somewhat wider than measurements given above, while the form on *J. communis* Seymour and Earle Ec.

---

1. Material in the Herbarium of the Division of Vegetable Phys. and Path. U. S. Dept Agrl. shows the following distribution: Starkville, Miss., Tracy, Mar., 1889. Broadwater 2388 Waite, Newfield, New Jersey, J. B. Ellis.
2. Prel. List Ia Uredineae Bull Dept Bot Ia Agrl Coll 1884: 162.
3. Rep. N. Y State Mus. Nat. Hist 26: 89.
   Bull Buffalo Soc Nat Sci 1: 68 Farlow Bull. Bussey Inst. 2: 225
   Exsicc Rav Fung. Am 272, 502. Ellis N. Am Fung 1083a Aecidium Ellis N. Am. Fung. 1084a on twigs of *Crataegus coccinea;* 1084b spermagonia Ellis and Everhart 2221a on *Crataegus parvifolia*, 2224b on *Cr. coccinea.*
   Ravenel's Fung Am 271
   Seymour and Earle Economic Fung. 234; 235, on *J. Virginiana* and *J. communis.* Aecidium 237, 236, 238.
   Von Thumen. Myc. Univ. 44.

Fung. 235 has more slender spores. The specimen from Glenwood Springs, Colorado, agrees pretty closely with Ravenel's Fung. Am. No. 271, and the description given by Farlow.[1] The aecidium spores are bright orange, spherical or somewhat angular 27-47^{u} in diameter, wall thick, punctate with distinct pores; spermagonia blackish on the fruit and stem. The peridial cells lining the cup are ovate, squarish, or pointed, closely united, 36-38^{u} x 50-55,^{u} walls thick and striate. Peridial cells in the quince are somewhat larger than in the fruit of Crataegus. This fungus is of economic importance, especially in eastern North America. It has certainly not been generally recognized in the west. The species occurs on Red Cedar as well as on *Juniperus communis*. Dr. Thaxter having found the fungus on the latter host at Kittery Point, Maine. The aecidium stage is common in the eastern states, but so far as we know does not occur in Iowa. It is represented in the herbarium of the Division of Vegetable Physiology and Pathology from the following points on *Pyrus arbutifolia*, Kittery Point, Maine, (Thaxter;) Amherst (S. T. Maynard;) Boston (W. K. Shaw;) Washington, D. C., (B. T. Galloway, 1226;) *Crataegus glandulosa*, Georgia; C. *coccinea*, Starkville, Miss.. (S. M. Tracy, 1744;) C. coccinea, Wakeman, Ohio, (W. B. Hull.)

A western species, *Gymnosporangium Nelsoni*, Arthur, has recently been segregated by Dr. Arthur[2] from what was called *G. clavipes*. It differs, however, from *G. clavipes*. Dr. Arthur[3] has given the following description of G. Nelsoni: Sporiferous masses globose, pulvinate cinnamon-brown ½mm. in diameter, solitary, or occasionally aggregated to form swellings; spores angular-oval or elliptical, not constricted at the septum, 22-26^{u} x 41-52,^{u} obtuse, usually narrowed toward each end; wall uniformly thin; pedicels hyaline, slender, firm, once to thrice the length of the spores; mycelium annual.

It occurs on the leaves or leafy branches of *Juniperus scopulorum* Sargent, Laramie Hills, Wyoming, May 10, 1895, No. 1886. Aven Nelson. The type collection has been rather widely distributed as *G. clavipes*, a species which it resembles, but from which it is readily distinguished by the slender pedicels and general habit.

I spent a day in Laramie Hills and was shown the trees on which the above *Gymnosporangium* occurred but

1. Gymnosporangia. l. c. 31.
2. Bull. Torrey Bot. Club, 28: 665.
3. *Gymnosporangium Nelsoni* sp. nov.

it was too late to collect the species. I noticed that the leaves of *Amelanchier alnifolia* were covered with a *Roestelia*, and I suggested that they were probably connected as there seems to have been no other *Gymnosporangium* in that vicinity. This *Roestelia* is described as new and referred to *R. Nelsoni* by Dr. Arthur.

R. NELSONI. "*Spermagonia epiphyllous*, in clusters on yellow spots prominent, nearly black, very numerous.

Aecidia hypophyllous in groups; peridia long, 2-4 mm., linear, somewhat curved, dehiscent by longitudinal slits toward the base, apex subacute, remaining closed; spores globose, 24-30μ in diameter, wall rather thick, chestnut-brown, minutely verrucose or smooth, pores about eight, without order, prominent.

"On leaves of *Amelanchier alnifolia*, Nutt., Laramie Hills, Wyoming, August 5, 1901. *A. Nelson*, No. 8597. An interesting species, and especially so as it appears to be the aecidial form of *Gymnosporangium Nelsoni*, described above. In a letter Prof. Nelson says: 'This was collected in the exact spot where *Gymnosporangium* was secured. There can be little doubt of the interrelation of the *Roestelia* and *Gymnosporanginm*.' Bird's nest distortions were not observed on the Roestelia. Prof Nelson states that he has not observed them. The spores resemble *G. nidus-avis* more closely than those of *G. clavipes*."

The *Amelanchier alnifolia* in close proximity to the Red Cedar had hundreds of leaves covered with the *Roestelia*. Scarcely a single leaf could be found which was not affected, and in picking the branches or shaking the bushes, clouds of spores came from the aecidium cups. A dozen or more of the aecidia could be seen on a single leaf. There are no experimental data at hand to show that there is a genetic connection between the two, but the close proximity of the Red Cedar on which this *Gymnosporangium* occurred, and so far as the writer knows, the only one, renders the evidence of connection reasonably certain. Another fact points to this conclusion. The Red Cedar is not abundant but is sparsely distributed over the hills and in narrow "draws." In one "draw," both the *Roestelia* and *Gymnosporangium* were abundant. Across the divide not more than 1,000 feet, both plants were common but neither *Gymnosporangium* nor *Roestelia* occurred. The small rock-covered slope was sufficient to prevent the infection of the Red Cedar from the "draw" containing the *Roestelia* nor were the *Gymnosporangium* spores carried over. Prof. Nelson told the writer that the *Gymnosporangium* was common on the same trees containing the fungus this year in 1900, but he had no data on the *Roestelia*. Presumably it was also abundant.

ECONOMIC CONSIDERATIONS. It may be of interest to observe here that the *Roestelia* from Laramie was found only

on the leaves and while hundreds of small fruits occurred, none of them were affected. This fungus seriously impaired the vitality of the Service berry, causing it to become dwarfed in comparison with healthy individuals and entirely preventing the production of fruit. It is singular that none of the fungus was found on the fruit. The leaves were entirely destroyed. Since the fruit of *Amelanchier alnifolia* is destined to be of some economic importance, it is worthy of attention.

The *Roestelia* on the fruit of *Amelanchier* found in the Grand Junction country and sent to Prof. Gillette, we have referred to *R. aurantiaca*, and also one sent to Prof. Paddock on the fruit of pear. It is extremely probable that *G. clavipes* occurs from Ashley to Grand Junction, Colorado, on *Juniperus occidentalis* var. *monosperma*, and that it may become a serious menace to the culture of the pomaceous fruits in that district. The quinces were quite generally affected on the western slope in 1901. Prof. Paddock has favored me with a *Roestelia* on pear fruit from Glenwood Springs, Colorado, and also one on the quince which was quite destructive in that state in Delta county during the past season which I would also refer to that species. Prof. Paddock[1] in a recent paper figures and describes the fungus.

The *Amelanchier* suffers more seriously than the Red Cedar and it is doubtful if the attacked plants ever entirely recover. Should this species of *Amelanchier* be cultivated extensively, this will become one of its most serious fungus diseases.

GYMNOSPORANGIUM NIDUS-AVIS THAXTER[2]

This species is common in the eastern states and was at first confused with *G. clavipes*, C. and P. Thaxter[3] has, however, shown that the species are distinct. There is no direct evidence of the occurrence of this fungus in the Rocky mountains except that the writer found "bird's nest distortion" on *Juniperus occidentalis* var. *monosperma* on Black's Fork in southwestern Wyoming. The season for its appearance had passed so that none of the spore masses could be found.

1. Bull. Col. Agrl Exp. Sta. 69: 18. *pl. 8.*
2. Bull. Conn. Agrl. Exp. Sta. 107: 6.
3. Bot Gaz. 14: 171.
   Bull. Conn. Agrl. Exp. Sta. 107: 6.
   Exsic. Seymour and Earle Econ. Fung. Aecidium 240.
   Ellis N. Am Fung. 1083b. Seymour and Earle. Fung. 239. Ellis and Everhart, N. Am. Fung. 3145.

General Characters. Spore masses irregularly globose or oval, small and distinct or elongate and confluent. The color is red brown; orange colored, expanded, and gelatinous when wet. Underwood and Earle call attention to the orange colored stain left on the hardened inner bark of the host. This is certainly true of the specimen collected by Ravenel many years ago. The leaves are larger than normal and spiny.

Microscopical Characters. Spores two-celled, ovate to sub-elliptical or fusiform, rounded or somewhat tapering

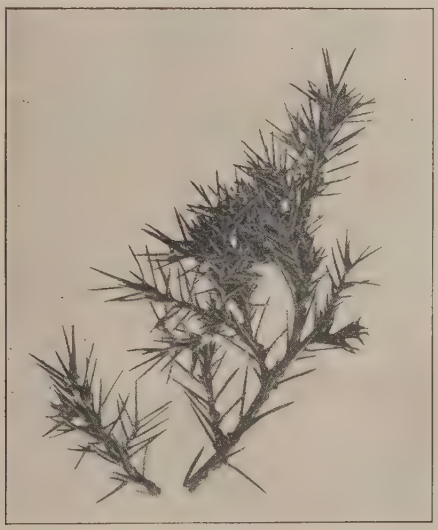

Fig. 10. Bird's Nest Fungus. *Gymnosporangium nidus-avis* on Juniperus Virginiana. Photograph, Charlotte M. King.

towards the apex, 15-18-22$^{\mu}$ x 45-55$^{\mu}$; pedicels long, hyaline, more or less inflated below when young. The mycelium, perennial in the leaves, branches and trunk, commonly produces the "bird's nest distortion."

Dr. Thaxter, who obtained cultures of the aecidial *Roestelia* stage describes it as follows:

"Spermagonia yellowish orange, preceding the aecidia by about ten days. Aecidia hypophyllous or more commonly on petioles, young shoots and especially on young fruit, densely clustered, brown at first subulate, then fimbriate; the peridia splitting to the base with its divisions slightly divergent. Peridial cells rather slender; the ridges somewhat prominent, sub-

labyrinthiform, horizontal or becoming inwardly oblique towards the extremities. Average measurements (toward the apex of the peridia) 7u x .018 mm. Aecidiospore smooth, spherical or irregularly oval to oblong; average diameter 25 mm."

The aecidium stage occurs on the leaves of quince and the stems, leaves and fruit of the serviceberry of the east (*A. Canadensis*,) probably also on the western species (*A. alnifolia*.)

Distribution. The Bird's Nest *Gymosporangium* is common along the Atlantic coast as indicated by Thaxter[1] and Farlow.[2] In the herbarium of the Iowa State College there are specimens collected by myself at Blue Hills, Mass., and at Riverhead, N. Y., by F. A. Sirrine. Two specimens from Iowa, one collected by E. W. D. Holway at Decorah, and another by L. R. Walker, Clermont, Iowa, and one from South Carolina by Ravenel, E. M. Freeman, (No. 977), and H. L. Lyon reports it from Minnesota. It is also reported by Earle[3] from Alabama although it is said to be rather rare.

In addition to the specimens of exsiccati in the herbarium of the U. S. Department of Agriculture, Division of Vegetable Physiology and Pathology, it is reported from Mississippi by Tracy. What appears to be the aecidium is also reported on the apple from Seabrooke, Maryland. (Lamson-Scribner and Viala.) This fungus is said to be extremely destructive at times to the cultivated apple.

Genetic Connection. Dr. Thaxter established a genetic connection between the bird's nest *Gymnosporangium* and Roestelia on Amelanchier. During the present spring, I received a fine lot of the Gymnosporangium from Mr. F. A. Sirrine, of Riverhead, Long Island, New York. The germinating material was sprinkled on the following plants on May 19: *Pyrus aucuparia*, *P. communis*, *P. Iowensis*, *the Mercer county crab*,[4] *Soulard crab*,[5] *P. malus*, *P. Sinensis*, *Amelanchier alnifolia*, *Crataegus punctata*, *C. pinnatifida*, *C. punctata*. The season for infection from *Gymnosporangium macropus* had nearly passed by. No leaves were found infected from natural sources of the *G. macropus* nor were there any evidences of aecidia from the *G. nidus-avis*.

---

1. Bull. Conn. Agrl. Exp. Sta. 107.
2. Gymnosporangia or Cedar Apples, etc. Fung. Am. No. 791.
3. Mohr. Plant Life of Alabama. Contr. U. S. Nat. Museum 6: 186. Underwood and Earle. Bull. Alabama Agrl. Exp. Sta. l. c. Bot. Gazette. 22: 257.
4. A form of *P. Iowensis*.
5. Hybrid of *P. Iowensis* and *P. malus*.

GYMNOSPORANGIUM CLAVARIAEFORME

This fungus was first described by Jaquin[1] as *Tremella clavariiformis* and later placed in the genus Gymnosporangium by DeCandolle.[2] Since Jaquin's time it has been referred to by numerous European writers, Duby,[3] Oersted,[4] Fries,[5] Tubeuf,[6] Hartig,[7] and others. In this country it has been studied carefully by Farlow[8] and Thaxter.[9] It is not uncommon along the Atlantic coast but in the Mississippi Valley has been found at only three points so far as I know, in northeastern Iowa by Holway,[10] by Walker near Clermont, also by Butler in Minneapolis, Minn. (97), Minn. Bot. Survey. The aecidium has been found in northern Wyoming by myself[11] on the fruit of *Amelanchier alnifolia* in the vicinity of Dome Lake and also by Miss Paddock and Mr. Reppert. This appears to be *R. lacerata* (Sow.) and is different from the fungus usually distributed as *R. lacerata* by American authors.

General Characters. The numerous or scattered cylindrical or somewhat compressed spore masses are occasionally forked at the apex from a quarter to half an inch high, yellowish brown in color when dry, bright orange when wet. The perennial mycelium causes a swelling which extends for some distance along the stem. The aecidia at first flask-shaped, later become cylindrical fimbriate and brown; they are numerous on yellow thickened spots on young fruit, stem and leaves. Spermagonia in great numbers develop on the yellow spots of the leaves.

Microscopical Character. Teleutospores are long and narrow, lanceolate, attenuated at both ends, constricted in the middle. On the outside of the sorus the spores are clavate, with the upper cell broad and obtuse at the apex, 14-20$^{\mu}$ x 70-120.$^{\mu}$ Spermagonia blackish, numerous. Aecidia flask-shaped to cylindrical. The peridial cells are brownish, becoming finely fimbriate, 20$^{\mu}$ x 50-75.$^{\mu}$ Spores brown, spherical, sometimes angular, or occasionally longer than broad; 19-24$^{\mu}$ in

1. Collectan 2: 174.
2. Fl. Franc. 2: 217.
3. Podisoma clavariaeforme Duby. Bot. Gall. 2: 281.
4. Podisoma clavariaeforme Duby. Bot. Zeit. 1867: 222.
5. Syst. Myc. 3: 508.
6. Pflanzenkrankheiten. 396
7. Textbook of the Diseases of Trees. 158
8. The Gymnosporangia, etc. 12
9. Notes on the Cultures of Gymnosporangia.
10. Prel. List of Iowa Uredineae. Bull. Bot. Dept. Ia. Agrl Coll. 1884: 162
11. H. H Hume. Fungi collected in Colorado, Wyoming and Nebraska. Proc. Dav. Acad. Nat Sci. 7: 250. Contr. Bot. Dept I. S. C. 15: 250.

diameter, although somewhat variable; in typical specimens, spherical to sub-globose, 20-28^{u} x 20-40^{u}; surface finely granular.

Economic Considerations. This species is decidedly destructive to the fruit of *Amelanchier alnifolia* in northern Wyoming. It prevents the formation of seeds and fruit. *Juniperus communis* is common throughout the Rocky mountain section, and it is more than likely that *G. clavariaeforme* is also abundant, but collectors have failed to secure it. Though usually found on Amelanchier, it also occurs on the apple. Judging by the material sent out by Dr. Galloway[1] it must be extremely destructive. It is reported as destructive in that host in Europe by Tubeuf.[2] Representative material may be found in numerous exsiccati. It may also occur on the wild crab (*Pyrus Iowensis*,) but this is unusual in the west. A specimen in the herbarium of the U. S. Dept. of Agiculture, Division of Vegetable Physiology and Pathology, collected by Prof. Holzinger may be referable to this species. The occurrence of the aecidium in Indiana (Underwood,) Illinois (Waite,) central Iowa (Pammel,) northeastern Iowa (King,) where the teleuto stage has also been found in two localities, and the occurrence of the aecidium in Nebraska (Williams 283,) Kansas (Kellerman,) Sheridan, Wyoming, (Pammel, Reppert, Paddock,) Montana (Seymour,) indicates its distribution across the country, probably to the Pacific coast.

Genetic Connection. From the results obtained by Thaxter, Tubeuf, Plowright and others, it is settled beyond a doubt that *G. clavariaeforme* is connected with *R. penicillata*, *R. lacerata* (Sow.) and much that has passed for this fungus on *Pyrus malus* and *P. coronaria* is *Roestelia pyrata*. Thaxter obtained positive infection results on *Amelanchier* and *Crataegus*.

On May 6th, the writer received from E. R. Walker, Clermont, Iowa, some fine material of *G. clavariaeforme*. The spores were germinating. The following species of trees were experimented with on the college grounds. The leaves of the trees were sprinkled with the germinating spores.

---

1. Columbia, Missouri. Galloway (1739.)
2. Pflanzenk. 296.
   Gymnosporangium, Exsiccati, Seymour and Earle, Econom. Fung. 241. Ellis. N. Am Fung. 273. Krieger Fung. Sax. 362. Sydow Ured. 1036 VonThumen. Myc. Univ. 1036. Briozi and Cavara Fung. parass. delle pianti 161.
   Aecidium. Seymour and Earle, Econom. Fung. 242a, 242b, 242c J. Eriksson, Fung. paras. scandin. 75,180, Sydow. Uredin. 585,134 Ellis, N. Am. Fung. 1086c, 185a. Krieger, Fung. Sax. 361. Ravenel, Fung. Carol. 96.

RESULTS OF INOCULATING EXPERIMENTS WITH G. CLAVARIAEFORME

Species.	Date of Sowing	No. of Leaves Sown	No. of Flowers	Results of Inoculations
Pyrus aucuparia	May 6	3		0
" communis	" "	7	9	0
" Iowensis	" 8	Leaves	Flowers	0
" Mercer County Crab	" "	5	5	Spermagonia
" Malus	" 6	5	5	0
" Sinensis	" "	7	9	0
Amelanchier alnifolia	" "	2	17	0
Crataegus pinnatifida	" 7	5	19	0
Crataegus mollis	" "	7	0	0
" punctata	" 8	7	0	0

It will be noticed that only in one case were Spermagonia produced. As these inoculations were all made out of doors, there is a possibility that they may have been *R. Pyrata*. In no case have any of the aecidia *Roestelia* of *G. clavariaeforme* been produced here at Ames by inoculation. The common *Roestelia* found at Ames is the *R. Pyrata*, and this is connected with the *Gymnosporangium macropus*.

METHOD OF TREATMENT

Several mycologists have carried on some investigations in spraying for these rusts. In 1892 I sprayed[1] several apple trees of the wild crab for the purpose of seeing whether this fungus might be controlled by treating with Bordeax mixture and ammoniacal carbonate of copper. Three applications were made; two applications with Bordeaux mixture, and the last with ammoniacal carbonate of copper. There was little benefit from spraying.

Col. Pearson, at Vineland, N. J., made an experiment in treating the cultivated apple for the same fungus, using sulphate of iron, two pounds of salt to one gallon of water. The first application was made before the leaves were out. Additional applications were made every three weeks with a solution containing sulphate of iron, six pounds; lime, four pounds; water, twenty-two gallons.

Prof. Galloway[2] states with reference to an experiment with Bordeaux mixture that the foliage remained fairly healthy, yet the benefit was not sufficient return for the labor expended.

Prof. L. R. Jones,[3] of the Vermont Agrl. Exp. Station reports an experiment carried on in the orchard of Mr. John E. Smith in South Burlington, Vt., in 1899. spraying with am-

1. Bulletin. Ia. Agrl. Exp. Sta. 13: 43.
2. Report. U. S. Dept. Agrl. 1889: 413.
3. Report. Vermont Agrl. Exp. Sta. 1890: 139.

moniacal carbonate of copper in the following proportions: One ounce copper carbonate distilled in one quart of ammonia first diluted in twenty-five gallons of water. Two sprayings were made; one on May 17th, and one on May 30th. The second treatment on May 30th was also with ammoniacal carbonate of copper, but was diluted by adding one-half more water than before. The result of this experiment indicated that there was no marked difference between treated and untreated leaves, as the following table shows:

Healthy leaves on tree sprayed	215	25	per cent.
Rusted " " " "	645	75	" "
Total	860	100	" "
Healthy leaves on tree not sprayed	450	23	per cent.
Rusted " " " " "	1541	77	" "
Total	1991	100	" "

The rust was not so abundant on the individual leaves of the sprayed trees as upon the leaves of the unsprayed trees.

Prof. Emerson[1] in a paper before the Nebraska Horticultural Society, reports as follows concerning the spraying for Cedar rust.

RESULTS OF SPRAYING FOR CEDAR RUST

Tree No.	Variety	When Sprayed	Per cent. of Leaves Rusted	Av. No. of Rust Spots per Rusted Leaf
1, 2	Wealthy (high land)	Not sprayed	30	1.4
3, 4	" " "	April 27, May 28	19	1.6
5, 6	" " "	April 27, May 9	12	1.7
7, 8	" " "	May 9, May 28	4	1.0
9, 10	" " "	April 27, May 9, 28	4	1.0
11–13	" (low "	Not sprayed	77	3.4
14–16	" " "	May 28	48	2.0
17–19	" " "	May 9, 28	9	2.0
20–22	" " "	April 27, May 9, 28	6	1.5
23	Jonathan	Not sprayed	48	2.4
24	"	Not sprayed	46	2.3
25	"	April 26	42	2.5
26	"	May 23	45	2.7
27	"	April 26, May 23	43	2.6
28	"	April 26, May 23	45	2.5
29	"	May 7, 23, May 7, 23	7	1.6
30	"	April 26	10	1.5

Prof. Emerson thinks that spraying at the right time gives excellent results, and that the time of spraying must vary with the season. The appearance of Cedar Apple fungi must be observed, and the application must be made at a time when they are in a germinating condition.

1. Ia. Homestead, 1905: 669., April 13.

Fig. 11—*Roestelia pyrata* on *Crataegus bipinnatifida.* a and b. Showing clusters of cups with the surrounding yellow spots. c. One of the clusters enlarged, showing individual aecidia. d. The same, with a few enlarged erect peridial cells e-g. *Roestelia pyrata* on Mercer county crab. e. A single leaf with two spots on the fungus. f. A single sorus g. Aecidia (cups) showing spreading peridial cells. Charlotte M. King.

Last year the germinating period had a long season. In Iowa we found the Cedar Apple Rust in a germinating condition from May to July.

Resistant Varieties. It is certainly true from the observations made in this state and other places that certain varieties are more resistant than others. The Oldenburg, Hibernal, Fameuse, and Canada Baldwin in our state are more or less resistant. Cooper's Early, Oldenburg, Early Harvest, Sweet June, Yellow Transparent, Red Astrachan, Maiden Blush, Ben Davis, Gano, Winesap, Mammoth Black Twig, Ralle's Genet, Northwest Greening, York Imperial and Grimes' Golden, are said to be resistant in Nebraska, while the Red June, Wealthy, Whitney, Iowa Blush, Jonathan, are susceptible to rust. In Iowa at least the Wealthy was more seriously affected than any other variety. The Wealthy is likewise affected in the East, and reports also indicate that the Ben Davis and Maiden's Blush are affected.

The Removal of Cedar Trees. It is certainly true that wherever a windbreak of Red Cedar occurs, or where these are extensively grown in nurseries, the apple trees in close proximity are affected with apple rust. In one orchard examined, the two rows next to the Red Cedar windbreak were seriously injured by rust, the trees along the other side of the orchard being practically free from the rust. It seems undesirable, therefore, to use the Red Cedar as a windbreak, or for ornamental planting, at least in close proximity to fruit trees. The Red Cedar, of course, is a valuable tree for these purposes, and where orcharding is a secondary matter, the farmer will perhaps prefer to let his cedars stand in spite of the fact that they introduce a danger to his apple trees.

Conclusion. The Cedar Apple fungus is widely distributed in the state, having been reported from Allamakee county to Shenandoah, Ida and Cherokee counties. Many of the nurseries report it as very destructive. There is no doubt of the connection between the cedar apple fungus which produces the gelatinous horns in the spring and the apple rust. Experiments made on the wild crab and cultivated apple in treating this fungus with Bordeaux Mixture and other fungicides, have not been very successful in this state on the wild crab, though somewhat better results were obtained in experiments made with the apple rust in Nebraska on the cultivated apple where drier conditions prevail. The removal of the cedar trees will accomplish also the removal of the apple rust.